In this way threads can be produced of great length, of almost any degree of fineness, of extraordinary uniformity, and of enormous strength. A quartz fibre one five-thousandth of an inch in diameter Mr. Boys had in constant use in an instrument loaded with about 30 grains. It has a section only one-sixth of that of a single line of silk, and it is just as strong. Not being organic, it is in no way affected by changes of moisture and temperature, and so it is free from the vagaries of silk which give so much trouble. The piece used in the instrument was about 16 inches long. Had it been necessary to employ spun glass, which hitherto was the finest torsion material, then, instead of 16 inches, he would have required a piece 1,000 feet long, and an instrument as high as the Eiffel Tower to put it in.

There is no difficulty in obtaining pieces as fine as this, yards long if required, or in spinning it very much finer. Dr. Royston Piggott has estimated some of them at less than one-millionth of an inch; but, whatever they are, they supply for the first time objects of extreme smallness the form of which is certainly known, and therefore one cannot help looking upon them as more satisfactory tests for the microscope than diatoms and other things of the real shape of which we know nothing whatever.

Since figures as large as a million cannot be realized properly, it may be worth while to give an illustration of what is meant by a fibre one-millionth of an inch in diameter. A piece of quartz an inch long and an inch in diameter would, if drawn out to this degree of fineness, be sufficient to go all the way round the world 658 times; or a grain of sand just visible — that is, one-hundredth of an inch long and one-hundredth of an inch in diameter — would make 1,000 miles of such thread. Mr. Boys has made use of fibres one ten-thousandth of an inch in diameter, and in these the torsion is 10,000 times less than that of spun glass.

As these fibres are made finer, their strength increases in proportion to their size, and surpasses that of ordinary bar steel, reaching, to use the language of engineers, as high a figure as 80 tons to the inch. While these fibres give us the means of producing an exceedingly small torsion, and one that is not affected by weather, it is also true that they do not show the same fatigue that makes spun glass useless. A peculiar property of melted quartz makes threads such as these a possibility. A liquid cylinder, as Plateau has so beautifully shown, is an unstable form. It can no more exist than can a pencil stand on its point. It immediately breaks up into a series of spheres. This is well illustrated in that very ancient experiment of shooting threads of resin electrically. When the resin is hot, the liquid cylinders which are projected in all directions break up into spheres. As the resin cools, they begin to develop tails; and when it is cool enough, i.e., sufficiently viscous, the tails thicken and the beads become less, and at last uniform threads are the result.

Now, in the case of the melted quartz, it is evident, that, if it ever became perfectly liquid, it could not exist as a fibre for an instant. It is the extreme viscosity of quartz, at the heat even of an electric arc, that makes these fibres possible. The only difference between quartz in the oxyhydrogen jet, and quartz in the arc, is that in the first you make threads, and in the second are blown bubbles.

CULTIVATION OF SUGAR IN PERSIA.

THE sugar-cane was introduced into Persia from its original home in Bengal at a very remote period. The first indisputable mention, says the United States consul at Teheran, of sugar by a Western writer, is that by Moses Chorencrisis, in the fifth century, who describes the sugar-cane as he saw it growing on the banks of the Karun River, which joins the Shott-et-Arab at the head of the Persian Gulf. In the olden times, and as late as the fourteenth century, the sugar-cane was much cultivated in Susiana, the country intersected by the Karun River, and principally near Ahwaz and Jundi Shapur. Susiana was then one of the principal intermediate commercial stations between the present towns of Dizful and Śhushter, and had its water from the Karun River by means of canals cut from the right bank some distance above Shushter, and from the Diz River by canals cut from the left bank, near the town of Dizful. With the decline of Jundi Shapur, in the thirteenth century, the canals were neglected, and the cultivation of sugar-cane necessarily ceased. The present Ahwaz is a small village of about fifty houses, on a mound which covers the ruins of a part of the former town. Hundreds of millstones or wheels, formerly used for squeezing the juice out of the cane, are lying about in all directions. Persian historians do not ascribe the ruin of Ahwaz to the failure of the water-supply, but to scorpions. They say that an Indian merchant, with the view of raising the price, bought up all the sugar he could, and stored it for a year or two. When he opened his stores, all the sugar had turned into scorpions. Millions of scorpions came out of the sugar-store, all the inhabitants of Ahwaz fled, and the city has remained a desert from that day. There is still current in Persia a proverb which says, "At Ahwaz sugar-cane produces scorpions;" and one of the Persian poets, referring to the ringlets of his mistress, says, "They are as deadly as the scorpions of Ahwaz." The only district in Persia where sugar-cane is now cultivated is Mazanderan, which is the principal rice-producing district, and it was probably introduced during the last century. The sugar-cane in Mazanderan requires twelve months to ripen; but the canes are small and poor, few being ever found thicker than a man's finger, and the produce is of very inferior quality, being dark and moist. Both of these defects in all probability arose from want of skill in the cultivation and preparation of this valuable plant. The sugar is mostly consumed in the province; a considerable portion, however, is exported to Gilan, and some to Russia. The canes are planted in slips with two or three joints, in February or March, and ripen about eight or nine months after, having then a height of about five feet. One mill turns out per day about 200,000 pounds of juice, and about 60 to 70 pounds of sugar. The juice, therefore, yields 30 to 35 per cent of sugar. Only raw sugar is manufactured in Mazanderan. There are no sugar-refineries. The raw sugar is sold at the place of manufacture in the villages at from three farthings to a penny a pound, and in the markets of Sari and Barfunish at from a penny to twopence a pound, according to quality. In some towns of Persia, principally Yezd and Ispahan, Jaru raw sugar was, up to a few years ago, refined, and made into loaf-sugar. The loaf-sugar made in Persia was seldom perfectly crystallized, and was on that account very soft; it was also more or less impure and dirty, the loaves not having been properly washed, and the green sirup not having been completely removed. The imported loaf-sugar becoming very cheap, sugar-refining in Persia ceased to be profitable. The general Persian word for "sugar" is *shakar*, "the sugar-cane" is *udi-i-shakar*, while "refined sugar" is *kand*, "a loaf of sugar" is *kelleh-i-kand*, "sugar-candy" is *nabat*. Persia is famous for its sugar-candy. This is made in the ordinary way, but is left to crystallize on strings in a bowl of earthenware or china. The strings are kept at the bottom of the bowl by a piece of lead, and at the top by strips of wood. When taken out of the bowl, it retains its shape, and is called *kasch-i-nabat*; i.e., a bowl of candy. Consul Schindler is of opinion that sugar-cane would thrive well in some districts of Persia and southern Persia, at altitudes of from 1,000 to 3,000 feet above the level of the sea. The plain of Bugh-i-Mailik, east of Shushter, at an elevation of 2,600 feet; that of Shapur, west of Shiraz, elevation 2,500 feet; those of Fihift and Rudbar, south of Kerman, elevation 2,500 feet, — appear to him to be eminently suited to the cultivation of the sugar-cane.

FRUIT-CANDYING INDUSTRY OF LEGHORN.

THE English consul at Leghorn says that that city occupies the first place in Italy, and perhaps throughout the Mediterranean, for the preparation of the candied citron and orange peel so largely used in all branches of confectionery — citron being brought for this purpose from Corsica, from Sicily, from Calabria and other southern provinces of Italy, from Tunis and Tripoli, and even from Morocco; while the candied peel of the fruit is exported to North America, to the United Kingdom, and to Hamburg for distribution throughout Germany. Sugar also is imported for the purpose of the manufacture from Egypt. The wood of the boxes in which the candied peel is packed comes from Trieste, and the immense earthenware vessels necessary for the saturation of the fruit in

sugar-sirup are made in the neighborhood of Florence. The oranges imported into Leghorn, whether for consumption or for candying, are nearly all brought from the islands of Sicily, Sardinia, and Corsica. In all the countries contributing the raw fruit for this industry, it is treated in the same manner for the over-sea passage. The fruit is simply halved and placed in hogsheads or large casks filled with a fairly strong solution of brine, the fruit being halved merely to insure thorough preservation of the rind by an equal saturation of the interior as well as the exterior surface. In these casks it arrives at the doors of the manufactory. The first process to which it is then subjected is the separation of the fruit from the rind. This is done by women, who, seated round a large vessel, take out the fruit, skilfully gouge out the inside with a few rapid motions of the forefinger and thumb, and, throwing this aside, place the rind unbroken in a vessel alongside them. The rind is next carried to large casks filled with fresh cold water, in which it is immersed for between two and three days to rid it of the salt it has absorbed. When taken out of these casks, the rinds are boiled, with the double object of making them tender and of completely driving out any trace of salt that may still be left in them. For this purpose they are boiled in a large copper caldron for a time varying from one to two hours, according to the quality of the fruit and the number of days it has been immersed in brine. When removed from this caldron, the peel should be quite free from any flavor of salt, and at the same time be sufficiently soft to absorb the sugar readily from the sirup in which it is now ready to be immersed. The next process to which the rind is subjected is that of a slow absorption of sugar, and this occupies no less than eight days. The absorption of sugar by fresh fruit, in order to be thorough, must be slow, and not only slow but also gradual; that is to say, the fruit should be at first treated with a weak solution of sugar, which may then be gradually strengthened, for the power of absorption is one that grows by feeding. The fruit has now passed into the saturating-room, where on every side are to be seen long rows of immense earthenware vessels, about four feet high and two feet and a half in extreme diameter, in outline roughly resembling the famed Etruscan jar, but with a girth altogether out of proportion to their height, and with very short necks and large open mouths. All the vessels are filled to the brim with citron and orange peel in every stage of absorption; that is to say, steeped in sugar-sirup of about eight different degrees of strength. This process almost always occupies eight days, the sirup in each jar being changed every day; and with vessels of such great size and weight, holding at least half a ton of fruit and sirup, it is clearly easier to deal with the sirup than with the fruit. To take the fruit out of one solution and to place it into the next stronger, and so on throughout the series, would be a very tedious process, and one, moreover, injurious to the fruit. In each of these jars, therefore, there is fixed a wooden well, into which, a simple hand suction-pump being introduced, the sirup is pumped from each jar daily into the adjoining one. A slight fermentation next takes place in most of the jars; but this, so far from being harmful, is regarded as necessary, but is not allowed to go too far. There is yet another stage, and that perhaps the most important, through which the peel has to pass before it can be pronounced sufficiently saturated with sugar. It is now boiled in a still stronger sirup of a density of forty degrees by the testing-tube; and this is done in large copper vessels over a slow coke fire, care being taken to prevent the peel adhering to the side of the vessel by gently stirring with a long paddle-shaped ladle. This second boiling occupies about an hour. Taken off the fire, the vessels are carried to a large wooden trough, over which is a coarse open wire netting. The contents are poured over this, and the peel distributed over the surface of the netting, so that the sirup, now thickened to the consistency of treacle, may drain off the surface of the peel into the trough below. The peel has now taken up as much sugar as is necessary. Next comes the final process, — the true candying, or covering the surface of the peel with the layer of sugar-crystals which is seen on all candied fruits. To effect this, a quantity of crystallized sugar (at Leghorn the same quality of sugar is used as is employed in the preparation of the sirup) is dissolved in a little water; and in this the now dried peel, taken off the wire netting, is immersed. The same copper vessels are used, and a mixture is again boiled over a slow fire. A short boiling will suffice for this the last process; for the little water will quickly be driven off, and the sugar, upon cooling, will form its natural crystals over the surface of the fruit. Poured off from these vessels, it is again dried upon the surface of the wire netting, as before described. The candying is now complete, and the candied peel is ready for the packing-room, to which it is carried in shallow baskets. In the packing-room may be seen hundreds of boxes of oval shape and of different sizes, for each country prefers its boxes to be of a particular weight; Hamburg taking the largest (of 15 and 30 kilograms), the United States preferring smaller (of 10 and 12 kilograms), while England takes the smallest (of 5 kilograms), and one containing about 7 English pounds.

BOOK-REVIEWS.

Force and Energy. A Theory of Dynamics. By GRANT ALLEN. New York, Longmans. 8°. $2.25.

IN this work the author presents a new view of some of the concepts of physical science. The current views he holds to be erroneous, and, though he says that he puts forth his work with profound diffidence, it is evident that he feels great confidence in its correctness. The essential point in his theory is the distinction he draws between force and energy, both of which he includes under the term "power." Power he defines as "that which initiates or terminates, accelerates or retards, motion." He then goes on to divide power into two varieties, — force, or aggregative power; and energy, or separative power. Among forces he reckons gravitation, cohesion, and chemical affinity; and among energies, heat, muscular power in many cases, and, in short, whatever separates bodies or particles from one another. This theory he first states in an abstract form, and afterwards proceeds to an account of the various actual concrete forces and energies in the universe, mechanical, chemical, and vital, endeavoring to show that his views are not only consistent with the known facts and laws of physical science, but are essential to a correct understanding of them.

As to the merits of Mr. Allen's views, we shall not now enter on any elaborate criticism; but certainly his use of terms is not accordant with the common practice either of scientists or of writers generally. The term "power" has always been used in philosophy to denote causality viewed hypothetically; as when we say that fire has power to melt wax, meaning that it will melt wax if the two are brought into contact. Force, on the other hand, is commonly used to mean what Mr. Allen calls power; namely, any cause that in any way affects motion. The distinction Mr. Allen draws between separative and aggregative powers is of course a real distinction; and yet he himself finds it impossible to maintain it with perfect consistency. Thus, he calls the motion of a falling body and the contraction of a cooling body, energies, although they are obviously aggregative; and his attempt to remove the inconsistency does not seem successful. We commend the work, however, to the attention of our readers, as it is well written and with earnestness of purpose, and will doubtless be provocative of thought.

Life of Charles Blacker Vignoles. By his son, Rev. OLINTHUS J. VIGNOLES. New York, Longmans. 8°. $5.

THE subject of this memoir was one of the pioneers in railroad engineering, a work which in its early development required far more inventiveness and fertility of resource than is the case now; and his son has done well in laying an account of his life before the public. The book is well written, and with as much impartiality as could be expected in so near a relative of the hero. Vignoles was born in the last decade of the eighteenth century, and lived to the ripe age of eighty-two. He lost his parents in early life, and went to live with his maternal grandfather, with whom he afterwards had an irreconcilable quarrel. On reaching manhood, he entered the army, and by the aid of influential friends and his own merits rose in a few years to the position of lieutenant; but the conclusion of peace after Waterloo deprived him of the hope of further advancement, and he came over to America, and went to work as a civil engineer. He was employed in South Carolina and other Southern States, and by his experience there prepared himself for the more difficult work of railroad engineering, in which